C. 2

PRIMARY MATHEMATICS TEXTBOOK ANALYSIS,
GRADES 1-3

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Modern mathematics curricula introduces concepts and operations earlier, de-emphasizes drill and rote learning, and emphasizes structural arithmetic through the utilization of various concrete aids (Nolan, 1964). The use of tangible apparatus for teaching the visually impaired mathematics is not new. However, mathematical aids have been primarily concerned with computation (Ritter, 1950). Recently, materials have been adapted and produced which promote understanding and aid in concept development (Nolan & Bruce, 1962). A continuing need for more sophisticated apparatus has been recognized by educators (Franks, 1970). Educational researchers have been working to develop appropriate apparatus to fill this need (Franks, 1971).

Problem

Before special tangible apparatus for the visually impaired can be developed, guidelines are needed to provide specifications and priorities for aids development. Such guidelines are often provided through some form of textbook analysis (Caton, 1969; Franks, 1971). Therefore, it was the purpose of this study to identify through textbook analysis the concept areas (eg. addition, measurement, geometry, etc.), their scope and sequence of development on each of the three primary grade levels, with the vocabulary and aids suggested as guidelines for tangible apparatus development.

Method

The most recent teachers' editions of the mathematics textbook series now being produced in braille at the American Printing House for the Blind (APH) were analyzed. These series were as follows:

a) Addison-Wesley (A-W)
(Eicholz, Martin, Brumfiel, & Shanks, 1967 & 1963)

b) Science Research Associates (SRA)
(Elementary Staff of the Educational Research Council of America, 1968)

c) Laidlaw (L-B)
(Gundlach, Welch, & Buffie, 1968 & McSwain, Brown, Gundlach, & Cooke, 1965)

d) Silver Burdett (S-B)
(Morton, Gray, Rosskopf, & Trafton, 1970)

e) Houghton Mifflin (H-M)
(Duncan, Capps, Dolciani, Quast, & Zweng, 1967).

Each series was color coded by the investigator. A pencil of an assigned color was used for initial recording of data from a series. If a subsequent series contained the same data, a check mark or page numbers and supplementary information was added to the original recording in the appropriate color. This procedure saved unnecessary time in rerecording the same data on different sheets, and made possible a frequency count for the series without further compilation of the data.

The initial recording of data from the textbooks was done on information sheets which have evolved from previous textbook analyses of the Educational Materials Research and Development Section, APH. These information sheets were also color coded. (Mathematics information sheets were pink.) Information sheets contained space for recording such data as grade level, concept area, concepts taught, vocabulary, and suggested aids for developing the concepts. Each textbook was examined lesson by lesson and relevant information was recorded. A sample information sheet appears in the Appendix.

Following the initial textbook analysis, the data was organized by general concept areas to indicate the scope and sequence of concept development on the three primary grade levels, the vocabulary used, and the suggested aids for developing each concept area in primary mathematics. The general concept areas identified were ranked according to their frequency of appearance in the five series on the three primary grade levels. Numbers in parentheses indicated the number of series which presented a particular concept at that level.

Textbook analysis indicated that many of the suggested aids overlapped general concept areas; i.e., the same aids were used for teaching a number of concepts. Consequently, all of the suggested aids identified in this study were categorized by type, and the information was consolidated for easy reference in one table. On this list were superimposed the aids recommended for development by the APH Institute on Instructional Materials Development for Visually Handicapped (Franks, 1970) and those recommended by Caton (1969) to supplement illustrations in braille textbooks.

Results and Discussion

Table 1 indicates the twelve general concept areas suggested by this analysis of primary mathematics textbooks and the number of series including these concepts on each of the three levels. Examination of the data revealed that seven of the concept areas were included on all primary levels in all textbook series. These important areas were set theory, addition, subtraction, our number system and place value, fractions, money, and measurement. Geometry was covered at all primary levels by four of the five series; the fifth did not introduce geometry until grade 3. Only one series introduced multiplication in grade 1; all series presented multiplication in grades 2 and 3.

Because of the variety of material covered in the concept area of measurement, it was advantageous to further subdivide this category. Table 2 presents this subdivision.

TABLE 1

Concept Areas Ranked by Frequency of Appearance in the Five Primary Textbook Series on Each Grade Level

	Grades		
Concept Areas	1	2	3
Set Theory	5	5	5
Addition	5	5	5
Subtraction	5	5	5
Our Number System and Place Value	5	5	5
Fractions	5	5	5
Money	5	5	5
Measurement	5	5	5
Geometry	4	4	5
Multiplication	1	5	5
Ordinal Numbers and Location	3	4	2
Division	-	2	4
Roman Numerals	-	2	2

TABLE 2

Subdivisions of Measurement Ranked by Frequency of Appearance in the Five Primary Textbook Series on Each Grade Level

		Grades	
Concept Area: Measurement	1	2	3
Linear	5	5	5
Liquid	5	5	5
Clocks	3	4	4
Calendars	2	3	3
Temperature	-	2	3
Weight	-	-	2
Dozens	-	1	1

Linear and liquid measurement were the most important subdivisions, appearing in all series at all grade levels. Clocks, surprisingly, did not appear in one series at all, and were not introduced until grade 2 in another.

Table 3 gives a brief, but detailed account of the scope and sequence of concept development on the three primary grade levels, with the vocabulary and the aids suggested for developing each of the concept areas in primary mathematics. Because vocabulary and aids cross primary grade levels, they are not divided and are intended to be used for all primary levels as required. A number appearing in parentheses after a concept indicates the number of series in which that particular concept appeared at that level. If no number is indicated, it can be assumed that that particular concept appeared in the textbook series as indicated for that level of the general concept area. An example of this is found under addition in Table 3. Although addition concepts are included in all five textbook series, the concept "Rounding off numbers and estimating answers", (level III, concept 4) is only included in one series as indicated by the (1).

TABLE 3

Scope and Sequence of Concept Development Including Vocabulary and Aids

Concept Area: Set Theory

Level	Vocabulary	Suggested Aids
I (5) 1. Set, a collection of objects 2. Comparison of sets by one-to-one correspondence of set members 3. Equivalent sets 4. Comparison of sets by numbers 5. Empty set, no members 6. Subset, "part of" a given set 7. Addition & subtraction with sets	array empty set equivalent sets fewer greater intersection of sets least less many matching members more most one-to-one correspondence pair partition set subset	abacus or bead frame counting objects regrouping set flannel &/or magnetic board & cutouts, numerals, & yarn set cards numeral cards squared paper small containers
II (5) 1. Symbols for "greater than" and "less than" 2. Intersection of sets, members contained in both sets 3. Multiplication with sets 4. Array, an orderly arrangement of a set into equal rows		
III (5) 1. Partitioning or dividing a set into subsets 2. Naming an array as the product of two numbers 3. Naming an array as the product of one subset plus the product of another subset 4. Division with sets		

TABLE 3 (continued)

Concept Area: Addition

I (5) 1. Ideas of equality & equations 2. Math symbols for addition 3. Horizontal & vertical forms 4. Commutative (order) principle 5. Associative (grouping) principle 6. Use of parentheses to add 3 numbers 7. Combinations through sums of 10 8. Zero, the identity element II (5) 1. Combinations through sums of 18 2. Two- & three-digit numbers without regrouping 3. A series of 3 or more one- or two-digit numbers 4. Two- and three-digit numbers with regrouping in one place III (5) 1. Two- to seven-digit numbers without regrouping 2. Two- to seven-digit numbers with regrouping in more than one place 3. Analyzing & solving story problems 4. Rounding off numbers & estimating answers (1)	add addend addition addition table combination equals equation estimated answer grouping principle (associative) order principle (commutative) parenthesis partition plus regrouping rounded off number solve sum	yardstick computer number line number strips or rods abacus or bead frame counting men regrouping set wire coat hanger & clip clothespins in colors flannel &/or magnetic board & cutouts, numerals, etc. plastic or sandpaper numerals set cards equation cards number & symbol cards peg board & pegs or golf tees pocket chart gummed circles rubber bands

TABLE 3 (continued)

Concept Area: Subtraction		
I (5) 1. Inverse relationship to addition 2. Inequalities & symbols of inequality 3. Math symbols for subtraction 4. Horizontal & vertical forms 5. Differences from sums through 10 6. The role of zero	combination difference equals equation inequality inverse minus solve subtract subtraction	yardstick computer number line number strips or rods abacus or bead frame counting men place value containers counting objects regrouping set flannel &/or magnetic board & cutouts, numerals, etc. plastic or sandpaper numerals set cards equation cards number & symbol cards peg board & pegs or golf tees pocket chart
II (5) 1. Differences from sums through 18 2. Two- & three-digit numbers without regrouping 3. Two- & three-digit numbers with regrouping in one place		
III (5) 1. Two- to seven-digit numbers without regrouping 2. Two- to seven-digit numbers with regrouping in more than one place 3. Analyzing & solving story problems		

TABLE 3 (continued)

Concept Area: Our Number System and Place Value

I (5)

1. Cardinal numbers & counting
2. Number sequence to 99
3. Reading & writing numerals
4. The meaning of 0
5. The meaning of 10
6. Expanded notation for 2-digit numbers

II (5)

1. Number sequence beyond 100
2. Relationships among the decades
3. The idea of grouping by tens
4. Even & odd numbers (3)
5. Positive & negative integers (1)
6. The meaning of 100
7. Expanded notation for 3-digit numbers

III (5)

1. Grouping by hundreds
2. Use of commas to separate periods in large numbers
3. Characteristics of the sums & products of even & odd numbers (3)
4. The meaning of 1000
5. The meaning of million, billion, etc.

ahead
back
behind
billion
closest
count
digit
empty set
end
even number
expanded notation
farthest
greatest
hundred
hundreds
hundreds' place
least
matching
middle
million
negative number
number
number line
numeral
odd number
one, two, three, etc.
ones
ones' place
place value
positive integer
set
skip counting
ten
tens
tens' place
thousands
zero

number line
number strips or rods
follow-the-dot puzzles
sequence chart to 100
decades chart to 200
abacus or bead frame
counting men
odometer
pennies & dimes
counting objects
regrouping set
wire coat hanger & clip clothespins in colors
flannel &/or magnetic board & cutouts, yarn, etc.
plastic or sandpaper numerals
numeral cards
word cards
pegboard & pegs or golf tees
pocket chart
squared paper
rubber bands

TABLE 3 (continued)

Concept Area: Fractions		
I (5) 1. Recognition of 1/2, 1/3, and 1/4 of a whole 2. Recognition of 1/2, 1/3, and 1/4 of a set II (5) 1. Fractions, names for numbers 2. Recognition of 2/4, 3/4, and 2/3 of a whole 3. Recognition of 2/4, 3/4, and 2/3 of a set III (5) 1. Fractions, parts of a whole 2. Fractions representing one whole 3. Mixed numbers, fractions greater than one whole 4. Recognition & meaning of 1/5, 2/5, 3/5, 4/5, 2/6, 3/6, 4/8, 3/9, & 1/10 (2) 5. Application of fractional concepts to measurement & money 6. Comparison of fractions	equivalent fractions fraction mixed number one-eighth one-fifth one-fourth one-half one-ninth one-sixth one-tenth one-third whole	fractional parts & wholes objects able to be cut apart (paper plates, apples, candy bars, paper geometric shapes) non-hardening modelling clay counting objects flannel &/or magnetic board & fractional parts measurement devices
Concept Area: Money		
I (5) 1. Penny 2. Nickel 3. Dime 4. Quarter 5. Cent Sign 6. Amounts of money less than one dollar	cent dime dollar dollar sign half-dollar money nickel penny quarter	real money is possible or toy money

TABLE 3 (continued)

II (5) 1. Half-dollar 2. Dollar 3. Equivalent amounts of one dollar 4. Place-value with pennies & dimes (2)		
III (5) 1. Dollar sign 2. Separating point 3. Equivalent amounts over one dollar		
Concept Area: Measurement - Linear		
I (5) 1. Length & height 2. Inch 3. Using a ruler II (5) 1. Half-inch 2. Foot 3. Yard 4. Centimeter (1) 5. Sums & differences of lengths III (5) 1. Selecting appropriate units of measurement 2. Using measurements to find area & volume 3. Mile 4. Quarter-inch 5. Meter (1) 6. Scale - one unit representing another - on maps (1)	area centimeter estimation foot half-inch height inch length line segment measure measurement meter mile quarter-inch scale unit volume yard	foot ruler yardstick meterstick lengths of ribbon or string

TABLE 3 (continued)

Concept Area: Measurement - Liquid		
I (5) 1. Pints 2. Quarts II (5) 1. Cups 2. Gallons III (5) 1. Ounces (3) 2. Half-pint 3. Half-gallon	cup gallon half-gallon half-pint ounce pint quart	calibrated cup containers for demonstrating all liquid measurement units pail
Concept Area: Measurement - Clocks		
I (3) 1. Hour 2. Half-hour 3. Associating typical daily activities with time II (4) 1. Quarter-hour 2. Five-minute intervals III (4) 1. Hours & minutes 2. Various notation for time 3. Seconds 4. Fractions of an hour 5. Fractions of a minute	clock clockface five-minute intervals half-hour half past halfway hour hour hand minute minute hand quarter hour second	clock with synchronized hands individual clocks other kinds of clocks & watches number lines 1-12 by ones and 1-60 by fives

TABLE 3 (continued)

Concept Area: Measurement - Calendars		
I (2)		
1. Day 2. Week 3. Month 4. Year	calendar date day month week year	calendar
II (3)		
1. Order of days of the week 2. Finding & reading dates on a calendar 3. Skip counting by sevens		
III (3)		
1. Length of months (1)		
Concept Area: Measurement - Temperature		
I		
II (2)		
1. Thermometer as a kind of number line 2. Degree 3. Associating high temperature with heat 4. Reading temperatures above zero	degree freezing point temperature thermometer	an outdoor thermometer a demonstration model of a thermometer individual thermometer vertical number line
III (3)		
1. Associating plus sign with temperatures above zero 2. Associating minus sign with temperatures below zero		

TABLE 3 (continued)

Concept Area: Measurement - Weight

I

II

III (2)

1. Pound 2. Half-pound 3. Ounce	half-pound ounce pound	scales (kitchen & bathroom)

Concept Area: Measurement - Dozens

I

II (1) & III (1)

1. Identification of sets of one dozen and one-half dozen 2. Construction of sets of one dozen and one-half dozen	dozen half-dozen	egg cartons word cards pictures of dozens (glasses, cupcakes, cookies, flowers, buttons, pencils)

Concept Area: Geometry

I

1. Identification of circles, squares, triangles, & rectangles 2. Comparison of different sized circles, squares, triangles, rectangles 3. Ideas of points & line segments (3) 4. Closed curve (1) 5. "The shortest distance between 2 points is a straight line" (1)	above after angle area before below between center center point chord circle closed compass congruent	ruler number line toys of different sizes plane models in wire and/or plastic in various sizes (Judy Property Blocks & Stick-O-Mats, square with a 10" diagonal, square corner, etc.)

TABLE 3 (continued)

II 1. Ideas of inside, outside, on, region (1) 2. Drawing & using points & line segments including diagonals (2) 3. Center, radius, & diameter of a circle 4. Square corners 5. Symmetry (2) 6. Congruence (1) 7. Simple closed curves including circles, squares, triangles & rectangles (1) 8. "Only 1 line can be drawn through 2 points, but many lines can be drawn through 1 point." (1)	cube cylinder diagonal diameter end point graph inside larger last left line line segment next opposite outside parallel parallelogram path plane point quadrilateral radius rectangle region right right angle roundness shape shortest sides simple smaller space sphere square square corner symmetric triangle volume	flannel or magnetic board & geometric shapes solid models (cube, etc.) compass & desk protector tracing paper simple street map squared paper book with square corners volleyball, basketball, baseball classroom globe magazine pictures of geometric shapes 1/4" wide strips thumbtacks heavy string crayons paste scissors
III 1. Regions of a plane (inside & outside) & properties of plane figures 2. Drawing circles with a compass (1) 3. Parallelogram & parallel lines (2) 4. Angle, exterior & interior angles (1) 5. Constructing right angles 6. Quadrilaterals 7. Cube & its properties (1) 8. Sphere (1) 9. Cylinder (1) 10. Constructing rectangles & squares by folding paper (1) 11. Families of lines through a point (1) 12. Family of circles through 2 given points (1) 13. Three points not on 1 line determine exactly 1 circle (1)		

TABLE 3 (continued)

14. Sum of the angles of a triangle (1) 15. Sum of the angles of a quadrilateral (1) 16. Surfaces of rectangles can be measured by square units (1) 17. Rectangles may be the same size (area covered) but have different shapes (1) 18. The smaller the unit square, the more units are needed to cover the rectangle (1) 19. Area equals length times width (2) 20. Volume (1)		
Concept Area: Multiplication		
I (1) 1. Addition of equal sets 2. Skip counting on the number line II (5) 1. Naming arrays 2. Math symbols for multiplication 3. Horizontal & vertical forms 4. Introduction of multiplication facts 5. Discovery of "zero" pattern 6. Discovery of "one" pattern	array cartesian product factor grouping principle (associative) multiple multiplication multiplication-addition principles (distributive) order principle (commutative) partition prime number product product set skip counting times	number line abacus or number frame counting objects regrouping set paper dolls & dresses different colored cup & saucers flannel board &/or magnetic board & cutouts, numerals, & symbols array & set cards equation (flash) cards number & symbol cards peg board & pegs or golf tees pocket chart simple street map squared paper

TABLE 3 (continued)

III (5) 1. Commutative (order) principle 2. Associative (grouping) principle 3. Distributive (multiplication-addition) principle 4. The long multiplication algorithm for two- & three-digit numbers as factors 5. The short mutliplication algorithm for two- & three-digit numbers as factors 6. Mastery of multiplication facts through the 10's 7. Product sets & cartesian products 8. Prime numbers (1) 9. Factors & multiples of 10, 100, & 1000 (4)		
Concept Area: Ordinal Numbers and Location		
I (3) 1. Ordinal numbers through tenth 2. Used to indicate position in a series	bar graph column eighth first fifth fourth grid ninth position row second seventh sixth stack tenth third	10 different small objects lettered or textured blocks word cards pocket chart
II (4) 1. Ordinal numbers expanded 2. Used to describe days in a year (1) 3. Pairs of numbers used to indicate location within a grid (1)		
III (2) 1. Bar graphs 2. Use of row & column for reading		

TABLE 3 (continued)

Concept Area: Division		
I		
II (2)		
1. Sets partitioned into subsets 2. Repeated subtraction 3. Inverse relationship to multiplication 4. Missing factor multiplication (basic multiplication facts)	dividing division divisor estimate quotient remainder subset	number line counting objects regrouping set flannel &/or magnetic board & sets of cutouts, numerals, etc. array & set cards number & symbol cards peg board & pegs or golf tees pocket chart squared paper several small containers
III (4)		
1. Math symbols for division 2. Horizontal & vertical forms with one-digit divisors 3. Estimation (3) 4. Discovery of "one" pattern 5. Division with remainders (2) 6. Long division algorithm (2)		
Concept Area: Roman Numerals		
I		
II (2)		
1. Roman numerals, a different way of expressing the names of numbers (3)	Arabic numerals Roman numerals	clock with Roman numerals table of contents with Roman numerals
III (2)		
1. Additive characteristics (1) 2. Subtractive characteristics (1)		

A compilation of the tangible apparatus suggested in the five textbook series is presented in Table 4. The eight subheadings--set collections, place value aids, number sequence aids, fraction aids, measurement devices, geometric aids, miscellaneous arithmetic aids, and general classroom supplies--were used for convenience in organization. Superimposed on this table are the aids recommended for development by the APH mathematics institute (Franks, 1970) and those recommended by Caton (1969) to supplement illustrations in braille textbooks. Many of the aids, especially those that have not been recommended in either of these previous studies, have been satisfactorily adapted for the visually impaired or are available commercially in a form which can be used by the visually impaired without adaptation.

TABLE 4

Primary Arithmetic Aids Suggested in
5 Textbook Series for Grades 1-3

Set Collections

- counting objects (washers, colored beads, spools, clip clothespins in 3 colors, sticks, tongue depressors, straws, checkers, poker chips, 2-color disks)
- different colored cups & saucers
- paper dolls & dresses
- toys of different sizes
- lettered or textured blocks
- 10 different small objects
- egg cartons

Place Value Aids

- containers labelled "Ones," "Tens," "Hundreds"
- counting men
- abacus or number frame
- real or toy coins & money
- 1,000 plain blocks
- regrouping sets (bundles of sticks, pop-together beads, etc.)
- Judy Place-Value Pegs

TABLE 4 (continued)

Number Sequence Aids

- number line
- number strips or colored rods
- follow-the-dot puzzles
- sequence chart to 100
- decades chart to 200

Fraction Aids

- fractional parts & wholes
- objects able to be cut apart to demonstrate (paper plates, apples, candy bars, geometric paper shapes)
- non-hardening modelling clay

Measurement Devices

- clock with synchronized hands
- clock with Roman Numerals
- yardsticks
- foot rulers (cm.)
- calendar
- thermometer for demonstration
- scales (kitchen & bathroom)
- calibrated cup
- liquid measuring containers
- meterstick
- outdoor thermometer
- individual thermometers
- individual clocks
- odometer

Geometric Aids

- magazine pictures of shapes
- models - (wire and/or plastic in various sizes) cube, square corner, square with 10" diagonal, etc.
- compass & desk protector
- volleyball, basketball, baseball
- classroom globe
- Judy Stick-O-Mats
- circular objects (coins, table tops, bottle caps, buttons, etc.)
- paper shapes (various sizes)
- 1/4" wide strips
- Judy Property Blocks
- 3-D Models (blocks)

Miscellaneous Arithmetic Aids

- peg board & pegs or golf tees
- flannel &/or magnetic board materials
- plastic or sandpaper numerals
- pocket chart & cards
- set cards (incl. arrays & dozens)
- equation cards (flash)
- number & symbol cards
- word cards
- simple street map

General Classroom Supplies

- flannel &/or magnetic board
- squared paper
- tracing paper
- pail
- wire coat hangers
- heavy string
- thumbtacks
- rubberbands
- yarn
- lengths of ribbon or string
- gummed circles
- crayons
- paste
- scissors
- book with square corners
- table of contents with Roman Numerals

__________ Recommended by APH Math Institute for development
_ _ _ _ _ Recommended by Hilda Caton to supplement illustrations

Summary and Conclusions

This study has identified twelve general concept areas discovered in the analysis of five primary mathematics textbook series and ranked them according to their frequency of appearance. Such identification and ranking should aid in establishing deficit areas where materials for the visually impaired need to be developed.

The scope and sequence of each concept area has been presented in detail including vocabulary and suggested aids. This information has been prepared for use in setting specifications for materials development and for use in developing and evaluating instructional units for tangible aids.

The suggested aids for primary mathematics instruction were often found to overlap the general concept areas. The suggested aids under eight subheadings were compiled to provide an easy reference for the educational researcher responsible for development of tangible apparatus for the visually impaired on the primary level.

This study should be regarded as a preliminary step in the materials development process. It identifies concept areas which may pose deficits in learning for the visually impaired, identifies aids for deficit remediation, and suggests priorities and guidelines for materials development.

APPENDIX

Information Sheet (Pink)

Concept Area: Addition Grade Level: 1

Purpose of the Unit:

Addition of 3 numbers

Use of parentheses

Cummutative and associative properties

A-W	Black	(pp. 196-203)
SRA	Red	(pp. 157-158, 169-170 217-218, 229-230, 235-236)
H-M	Blue	(pp. 175-179, 216-218 232, 277-280, 285-286, 292, 307, 313)
L-B	Green	(pp. 140-146, 187-189, 191-192)
S-B	Brown	(pp. 154-156, 161-163, 166-167, 171, 175-177, 179, 180, 187-189, 194, 196, 205, 218, 220, 222, 230, 234, 238)

Vocabulary:

partition	(Black)
set	(Black)
addend	(Black)
sum	(Black)
parentheses	(Black)
commutative	(Black)
associative	(Black)
subset	(Green)
column	(Brown)

Suggested Aids:

clothespins	(Red)
ten-frame	(Red)
set cards	(Red)
numeral cards	(Red)
flannel board	(Blue)
pocket chart	(Blue)
tri-colored objects	(Blue)
flannel board cutouts	(Blue)
yarn	(Blue)

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